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PROFESSIONAL INTERESTS:

Maxwell's equations, simulation and parameter identification for dispersive wave phenomena.
Finite difference numerical methods for differential equations.
Applications of object oriented software design (OOD) to high performance scientific computing.

EDUCATION:

Doctor of Philosophy, Computational Mathematics September, 1998
North Carolina State University, Raleigh, NC

Thesis advisor: Dr. H.T. Banks

Thesis title: Modeling, Analysis and Implementation of Forward and Inverse Problems in One Dimensional Electromagnetic Scattering with Differential and Hysteretic Polarization Models

Bachelor of Science, Applied Mathematics and Operations Research May, 1993
Harvey Mudd College, Claremont, CA

Graduated with High Distinction and Honors in Mathematics.

Advisor: Dr. A. Benjamin

Research topics: Combinatorics. PDE models of solid-state devices

PROFESSIONAL EXPERIENCE:

Postdoctoral Research Associate: LANL, Oct. 1998 – Present

- Developed and documented applications in PDEUM library for scientific computing
- Developed implemenetaions of perfectly matched layers for electromagnetic simulations

Research Assistant: NCSU, Sep. 1997 – Oct. 1998

- Created project to develop extensible scientific C++ code
- Furthered computational investigation into polarization behavior of dielectric materials and methods for parameter identification

Visiting Student Scientist: Los Alamos National Laboratory, Jun. 1997 – Aug. 1997

- Joined an on-going project for the development and testing of scientific C++ code
- Extended existing code to perform electromagnetic wave simulations

GAANN Fellow: NCSU, Sep. 1994 – May 1997

- Department of Education Graduate Assistance in Areas of National Need Fellowship
- Collaborated with researchers at Armstrong Laboratory, Brooks AFB
- Assisted Prof. Banks and Prof. Tran in teaching graduate level modeling course

CRSC Fellow: NCSU, Aug. 1993 – Sep. 1994

- Center for Research in Scientific Computation, NCSU
- Worked with Prof. H.T. Banks on modeling polarization behavior of dielectric materials

PROFESSIONAL ACTIVITIES:

Organized *Arizona Days 2000*. January 28-29, 2000. A joint workshop between the CNLS and the mathematics department of the University of Arizona.

COMPUTER EXPERIENCE:

FORTRAN, C, C++ programming on UNIX platforms

Experience with Object Oriented Programming/Design issues and applications to scientific programming

PROFESSIONAL MEMBERSHIPS:

Society for Industrial and Applied Mathematics (SIAM)

Pi Mu Epsilon, Honorary Mathematics Society

INVITED TALKS:

“Time, Frequency and Time-Frequency Domain Methods for Dielectric Parameter Identification” Computation and Control VII, Bozeman, MT. August, 2000.

“Distributed Parameter Estimation for Maxwell’s Equations” SIAM Conference on Control and its Applications, Jacksonville, FL, May 1998.

“Electromagnetic Parameter Identification” AMS-IMS-SIAM Joint Summer Research Conferences, Mount Holyoke College, South Hadley, MA, June 16–20, 1996.

“Parameter Identification for Maxwell’s Equations” annual meeting of the Southeastern Atlantic Section of SIAM, Clemson, SC, March 28–30, 1996.

PUBLICATIONS:

- [1] H. T. Banks and M. W. Buksas. Electromagnetic interrogation of dielectric materials. Technical Report CRSC-TR98-30, NCSU, October 1998.
- [2] H. T. Banks and M. W. Buksas. A semigroup formulation for electromagnetic waves in dispersive dielectric media. *College de France Series on Partial Differential Equations and their Applications*, 2000. To appear. See also Technical Report CRSC-TR99-34, NCSU, November, 1999.
- [3] H. T. Banks, M. W. Buksas, and T. Lin. *Electromagnetic Material Interrogation Using Conductive Interfaces and Acoustic Wavefronts*. Frontiers in Applied Mathematics. SIAM, Philadelphia, PA., 2000. To appear.
- [4] H. T. Banks, M. W. Buksas, and Y. Wang. A time domain formulation for identification in electromagnetic dispersion. *Journal of Math. Systems, Estimation and Control*, 8:257–260, 1998. See also: Technical Report CRSC-TR96-30, NCSU, October, 1996.
- [5] M. W. Buksas. *Modeling, Analysis and Implementaion of Forward and Inverse Problems in One Dimensional Electromagnetic Scattering with Differential and Hysteretic Polarization Models*. PhD thesis, College of Physical and Mathematical Sciences, North Carolina State University, 1998.

PUBLICATION SUMMARIES:

- [1] H.T. Banks, M.W. Buksas, *Electromagnetic Interrogation of Material Properties of Dielectrics*

This paper includes the derivation of the well-posedness results given in [4]. A scheme is presented for the numerical solution of the equation with the convolution model of electric polarization. Results illustrating the dispersive character of the medium are presented. Included is a discussion of specific issues in the estimation of parameters which describe the electromagnetic properties and geometry of the interrogated material. An estimation method designed to address these issues is demonstrated with examples.

- [2] H.T. Banks, M.W. Buksas, *A Semigroup Formulation for Electromagnetic Waves in Dispersive Dielectric Media*

We consider Maxwell systems with instantaneous conductivity and nonlocal in time (hysteretic) polarization laws which are characteristic of dispersive dielectric media. We formulate such systems in an operator theoretic framework and show that, under certain conditions on the dielectric response function, the resulting systems generate C_0 semigroups. It is shown that multiple Debye polarization models are included in those for which a semigroup formulation is possible.

- [3] H.T. Banks, M.W. Buksas, T. Lin, *Electromagnetic Material Interrogation Using Conductive Interfaces and Acoustic Wavefronts*

This monograph includes the final results of the estimation problem described in [1] and [4]. Additional material is included describing an identification problem arising in electromagnetic-acoustic coupling phenomena.

- [4] H.T. Banks, M.W. Buksas Y. Wang, *A Time Domain Formulation for Identification in Electromagnetic Dispersion*

In this paper we present a time domain approach for the investigation of dispersion mechanisms of a medium in electromagnetic field problems. Maxwell's equations coupled with a generalized electric polarization model are considered. The polarization is given in terms of a convolution of the electric field with an impulse response function, or as a differential equation driven by the electric field. Existence, uniqueness and continuous dependence of solutions on data are presented for a one-dimensional dispersive medium case. Numerical solutions with a differential model of polarization are given which illustrate the dispersive character of the medium. A technique is presented for estimating the electromagnetic parameters of the medium using the error between the numerical solutions and observed data. By using numerical solutions with added noise in lieu of observed data, the sensitivity of the parameters in a particular polarization model are demonstrated.

- [5] M.W. Buksas *Modeling, Analysis and Implementaion of Forward and Inverse Problems in One Dimensional Electromagnetic Scattering with Differential and Hysteretic Polarization Models*, Ph.D. thesis.

We begin with the derivation from Maxwell's Equations of equations describing the interaction of planar electromagnetic waves with dielectric materials. This derivation is completed by the addition of constitutive laws represented as differential equations or as the convolution of the history of the electric field.

We develop numerical schemes which use Galerkin finite elements to discretize the space variable, creating a differential system of equations. For the hysteresis formulation, another Galerkin approximation is used for the history of the electric field and the approximation of the hysteresis integral. Using these schemes, we simulate brief pulses of high-frequency electromagnetic waves impinging

upon a homogeneous slab of material which demonstrate the same precursor formation found in frequency domain analyses of these problems. The simulations are used in the inverse problem, where we attempt to recover the values of the parameters from measurements of the electric field reflected off the surface of the slab. Our results indicate that with certain exceptions, the parameter values can be recovered in the presence of noise of magnitude up to 5% of the magnitude of the signal. For experiments using the Debye model, a hybrid technique is presented for estimating both the physical parameters and the thickness of the slab.

The software written to perform the numerical computations described above is made part of a project to develop a re-usable library of code for scientific computing. We chose the object-oriented language C++ for this purpose with the intention of using specific features to facilitate the development of the library.